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ELECTRIC ARC WELDING OF ELEKTRON IN AN ARGON ATMOSPHERE

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Magnesium alloys have a low specific gravity (1.76 grams per cubic centimeter), a high tensile strength (of the order of 20-30 kilograms per square millimeter), and good casting and forging properties. They are used in various branches of the national economy.

Gas welding of magnesium alloys with the acetylene-oxygen flame is carried out using a flux consisting of chlorine compounds. Cleaning the flux off the seams after welding is extremely laborious, especially in angle and T joints. The corrosion resistance of the structure is considerably lowered by the particles of slag which remain.

Seeking a more efficient welding process, the All-Union Scientific Research Institute for Autogenous Working of Metals has carried out research work on mastering the electric arc welding of Elektron in an argon atmosphere. This alloy has the greatest corrosion resistance of all the magnesium alloys. However, rapid oxidation and low burning temperature of magnesium make the welding process difficult.

The specimens were welded using both DC and AC power supplied from a Komsomolets-type welding generator and transformer with an oscillator. Details of the process are as follows: argon gas from a cylinder passes through an electromagnetic cutout directly to the blowpipe. The cutout is switched on and off by a push button switch on the blowpipe. The air-cooled blowpipe, specially designed and manufactured, is intended for a current of 15 amp and weighs 370 gm. It is provided with a set of tips for use with wolfram electrodes of various diameters. The sizes of the holes in the tips were ascertained experimentally for electrodes of various diameters. In this connection, the gas stream must satisfy the following requirements: (1) the puddle must be protected on all sides,

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(2) the arc must burn evenly, and (3) molten metal must not be blown out of the puddle.

The expenditure of gas must be the minimum necessary to fulfill the above conditions.

The diameters of the electrodes and the orifices in the tips satisfying the above requirements should be, respectively, as follows (in millimeters): 2.5 and 4.2; 3 and 6; 4.7 and 8. Experiments were made on 150 x 90 mm sheets, 1.2, 1.5, 3 and 5 millimeters thick. The 5-millimeter sheets were prepared with 90 degree V-shaped grooves in which the seams were built up. Some of the sheets were built up in the hot state, i.e., immediately after the basic seam had been deposited. Others were built up after complete cooling. The filler material was cut off in strips from sheets of the basic metal.

Thin material (1.2 and 1.5 millimeters) warps considerably during welding and burns through at the joints. At Elektron backing was used to avoid this, the sheets being held against it by means of clamps. (The 5-millimeter sheets were welded without clamps in a free position.) Slots of various depths and widths were cut in the backing in order to enable the reverse side of the seam to be built up.

The following facts were established as a result of the experiments: It is impossible to weld magnesium alloy using DC current with the electrode negative because under these conditions magnesium oxide is formed very quickly. This covers the metal with a thick layer of white deposit and prevents the filler metal from fusing with the basic metal. Drops of filler metal roll along the deposit-covered surface of the joint and burn, leaving behind them a black, crinkled dross in the form of a coating. The edges are not thoroughly melted. The surface of the seam is drawn together by the thin film. Pronounced splashing is observed during welding. Magnesium oxide is not formed when reverse polarity is used. The welding seam is well formed, due to the melting of the edges of the basic metal. The arc burns evenly and there is no splashing.

A definite position of the blowpipe is necessary to ensure good gaseous protection of the basic metal and the filler rod. When adding filling material by hand, the angle between the sheets and the electrode should be 80-90 degrees and the angle between the electrode and the filler, 90 degrees. If the angle between the electrode and the sheets is altered, the molten metal is blown upward, bubbles are formed, and very porous seams result. The filler metal burns before it falls into the molten puddle and forms a white deposit. Decreasing the angle between the electrode and the filler material also leads to premature melting and burning of the latter.

Normally, 5-6 millimeters of electrode protrudes from the tip. Increasing the length of the electrode has a deleterious effect on the gas production of the seam; a black-brown deposit appears and part of the filler metal burns. Decreasing the length of the electrode interferes with the normal burning of the arc. The globule which usually forms at the end of the electrode covers the orifice of the tip and prevents egress of the gas. The formation of a globule at the end of the electrode is characteristic of reversed polarity DC welding. The opposite is the case with AC welding: the end of the electrode is drawn out and assumes the shape of a sharpened pencil.

AC welding gives an even, fine lamellar seam, but it is covered with a thin layer of deposit which interferes with the introduction of filler material. The seams obtained with DC are bright and free from any kind of deposit.

The welding process is outwardly the same, regardless of whether pure or commercial argon is used. In both cases the arc burns with sufficient stability and the seam obtained is clean, bright and free from deposit.

The cleanliness of the edges of the sheets and filler is of great importance when welding with DC and even more so with AC. Any burr or irregularity which remains after mechanical cutting will burn in the atmosphere of the arc before the main body of the filler melts. This forms a white deposit which complicates welding considerably.

Results showed that the strength of the welded joint varies from 75 to 90 percent of the strength of the basic metal. The purity of the gas has no influence on the strength of the weld. In some cases the ultimate tensile strength of specimens welded with commercial argon was higher than that of specimens welded with pure argon.

Specimens welded under different conditions were subjected to metallographic examination. The slides prepared were etched for a few seconds in a 0.5 percent aqueous solution of HCl, washed in alcohol, and again etched for a few seconds in a 2.5 percent aqueous solution of HNO_3, after which they were washed in alcohol and examined. It was established as a result of the investigation that the structure of the welded seams was satisfactory for Mark MA-1 magnesium alloy welded in an argon atmosphere.

Metallographic analysis showed that full penetration is attained during the welding process (both for 1.5 and 5-millimeter sheets). The transition from the deposited to the basic metal is smooth and takes place without appreciable overheating of the basic metal, and the joint is free from cracks.

When welding sheets of a thickness of 5 millimeters and over, it is necessary to preheat them before depositing the second seam. If this is not done, cracks appear, and the metal deposited is contaminated with oxides to a considerable extent. This can be explained by the fact that the oxide film which forms when the first run cools does not rise to the surface when the second run is deposited, but remains in the deposited metal. This type of defect was not found when the second layer of a V-shaped joint was welded on heated sheets. All this shows the necessity of preliminary heating for parts 5 millimeters and more thick.

Microscopic examination of a seam welded in an atmosphere of commercial argon revealed a small amount of magnesium nitrides, which had no effect on the ultimate tensile strength of the weld.

Welded pipe joints can be made by using round backing pieces, the diameter of which should be considerably less than that of the pipe. The backing pieces assist heat removal and eliminate burning through. However, material 5 millimeters thick was welded without these backing pieces. The current used for welding angle joints is 30-35 percent less than that required when welding with backing pieces and clamps.

In order to test the corrosion properties of the welded joint, specimens welded with pure and commercial argon were immersed in sea water and kept there for 30 days. In every case the basic metal corroded while the seam remained untouched. This is due to the purity of the metal in the seam and the absence of the particles of flux which usually remain behind after a gas-welded seam has been cleaned.

The following conclusions were drawn as a result of the investigation:

1. Mark MA-1 magnesium alloy can be arc welded satisfactorily in an atmosphere of argon without using flux. Various types of joints can be welded. The strength of the weld is 70-90 percent of the strength of the basic metal.

2. Pure and commercial argon can be used for welding Mark MA-1 Elektron.

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3. In order to assist heat removal and reduce warping, it is recommended that a backing piece be used when welding articles made of MA-1 alloy sheet up to 3 millimeters thick.

4. The edges of the joints and the filling material should be free of irregularities and burrs before welding.

5. There is a definite position for the blowpipe. The angle between the part and the electrode is 80-90 degrees and the angle between the filler rod and the electrode is 90 degrees.

6. A high-quality joint is assured by following the technical data for DC welding as determined experimentally [redacted] 50X1-HUM

7. The current should be reduced by 30-35 percent when welding joints without clamps.

8. Argon-arc welding can be done with DC (reverse polarity) and AC. The surface of the seam is cleaner and brighter when DC (reverse polarity) is used than when AC is used.

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